On the bulk silicate composition of carbonaceous chondrites

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Introduction:

The bulk compositions of the stony meteorites have been dominated by silicates and oxides. The one part of meteoritic minerals came through different grade of the chemical and/or physical transformations during the formation of the Solar-System. There are ancient mineral constituents, which survived the early stage of the evolution of the Solar-System and they appears original form: presolar dust grains. Primitive meteorites contain presolar dust grains: silicates, oxides, nanodiamonds, silicon carbide graphite, silicon nitride. The dominant sources of dust grains are the AGB stars and supernovae. The presolar silicate abundance is greater than the abundances of other presolar minerals [1].

Carbonaceous chondrites (CC, c-chondrites) are primitive meteorites with significant silicate and oxide amounts, some of them contain a relatively larger amount of elemental carbon (diamonds, graphite) and carbon-based compounds (silicon-carbide, different organic compounds). They are composed mostly of chondrules, inclusions and the fine-grained matrix. C-chondrites can be classified according to that their parent bodies formed in different regions of the early Solar-system. Accordingly, different CC-groups may distinguished as CI, CM, CV, CO, CR, CK, and CH type chondrites [2]. The groups are further divided into different subgroups.

Similarities and significant differences also appears in the abundances of given compounds in the different chondrites depending on the formation conditions of their parent bodies. For instance, the bulk composition of Allende matrix is Fe-rich obtained by Inoue et al. [3], the CM2 Murchison meteorite is an organic rich carbonaceous chondrite [4]. Chemical similarities appear between CM and CO chondrite chondrules [5], while considerable differences show the Murchison (CM2) and the Allende (CV3) chondrites in carbon content of the matrix.

In carbonaceous chondrites, highly forsteritic (Mg_2SiO_4) olivine can be found for example in the chondrules, in the (Amoebid Olivine Aggregates (AOA) and in the grains and aggregates embedded in the matrix. Fayalitic olivine (Fe_2SiO_4) is also identified in the mineral structures, but its amount is smaller than that of the forsterite. Enstatite ($MgSiO_3$) and ferrosillite ($FeSiO_3$) are also known in the mineral textures of chondrites.

Bulk silicate composition of c-chondrites The investigation for characteristics of silicates based on in detail the Kaba primitive CV3 c-chondrite [6], otherwise we studied the pure matrix material of the Allende CV3 c-chondrite with the concerning data utilized from the results of Inoue N. et al. 2004 [3]. We determined the Mg/Fe ratio in the silicates and the results have been summarized in the Table 1.

Kaba (CV3) mineral structure	Mineral sample	FeO(wt%)	MgO(wt%)	Mg/Fe
Porphyritic chondrule	Forsterite Fo1-1	0.30	55	Mg*0.993*Fe*0.007*
Granular ol-px chondrule	Forsterite Fo3-1	0.89	54.99	Mg*0.98* Fe*0.02*
	Forsterite Fo3-2	1.02	54.70	Mg*0.976*Fe*0.024*
Isolated olivine grain	Forsterite Fo8-2	0.21	56.91	Mg*0.995*Fe*0.005*
Comlicated aggregate	Fayalite Fa9-2	68.05	0.26	Mg*0.003*Fe*0.997*

Allende (CV3)				
Pure matrix	A1	36.60	19.19	Mg*0.407*Fe*0.593*

Table 1. The FeO and the MgO abundances in different mineral structures of the Kaba meteorite (CV3) and in the bulk chemical composition of the matrix of the Allende (CV3) chondrite. The Mg/Fe ratio is calculated from the basic data that are taken from Gucsik A. et al. (2013) and from Inoue M. et al. (2004).

As seen in the Table 1, the mineral components of the Kaba meteorite is rich in highly forsteritic (Fo>0.99) olivines, while the bulk silicate composition of the Allende matrix enriched in iron. In fact, the mineral composition of chondritic meteorites has been dominated by silicates. The elemental abundances of chondrites approximately consistent with the cosmic abundances of elements and minerals. The high ratio of Mg, Si, and O in meteorites refers to the dominance of magnesium silicates for the case of chemical characteristics of the Galaxy as opposed to the abundances of Fe-, Ca-, Al-silicates.

Summary: The carbonaceous chondrites are known to have been dominated by silicates but they may contain carbonaceous mineral constituents in small amounts. The bulk composition of the planet-building materials in the most circumstellar enviroments is assumed to be chondritic-like.

References

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